Liquid Metal Experiment

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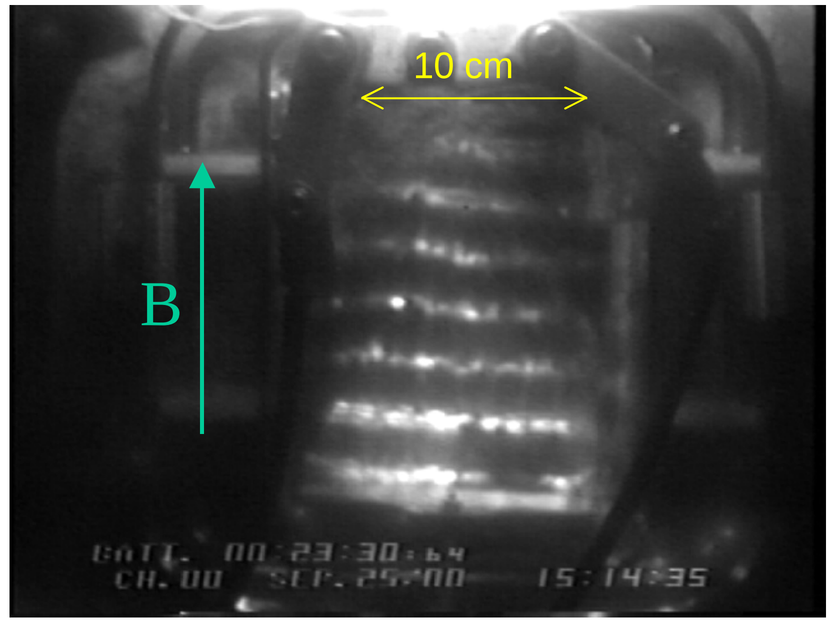
- **Motivations**
  - **MHD turbulence is an important topic in basic plasma physics and astrophysics.**
  - **Potential fusion applications of liquid metal walls require a better understanding of free-surface liquid metal MHD**
- **Using easy-to-handle metals in small scales, goals of LMX are to study**
  - **When and how do MHD effects modify surface stability, either in linear or nonlinear regimes?**
  - **When and how do MHD effects modify a free-surface flow?**
  - **When and how do MHD effects modify thermal convection?**

Surface Waves Driven with and without Magnetic Field

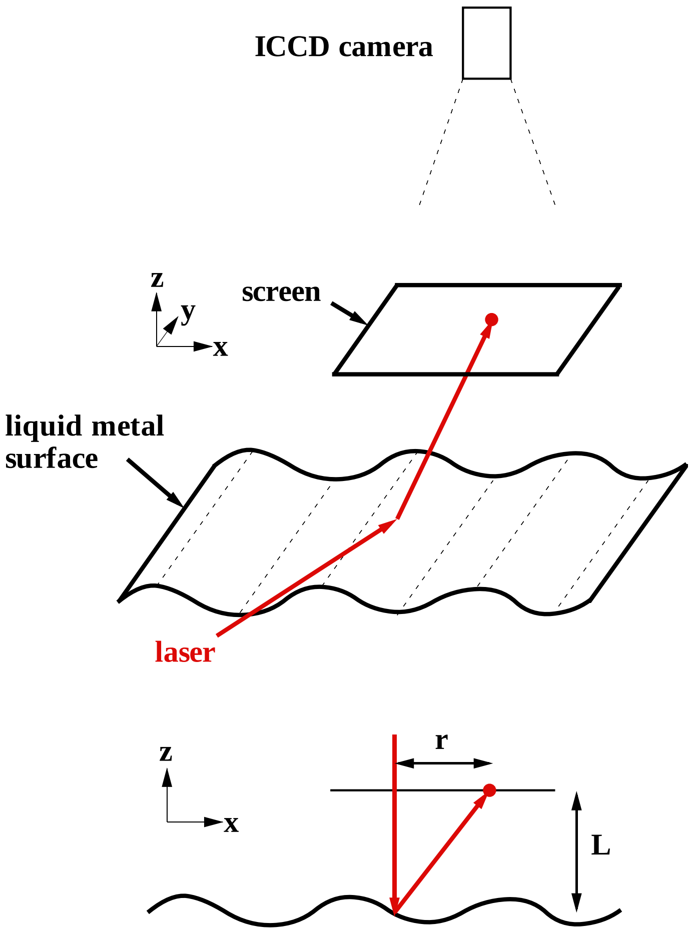
- The gallium is melted in a container placed in a hot water tank.
- A wave driver system (including a paddle, an inductive driver, and amplifier) is used.
- Two pairs of coils provide up to 600G of magnetic field.
- A PC is used to control and data acquisition.

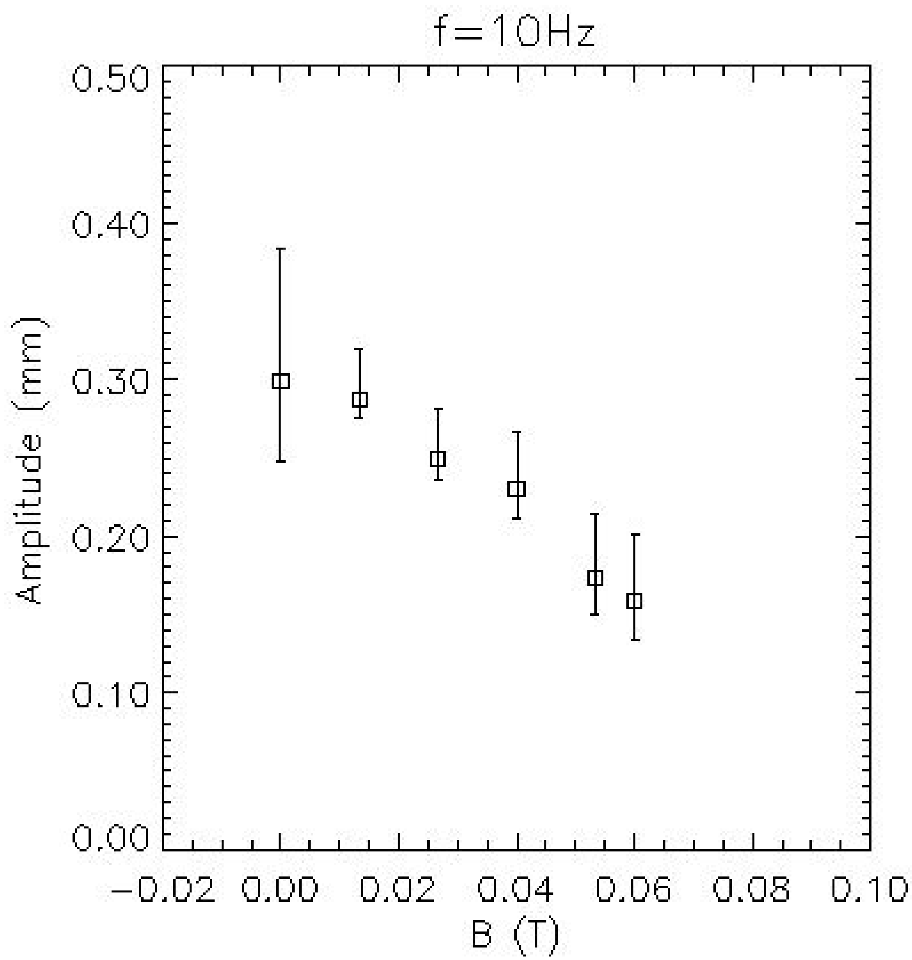
f=10Hz w/ B=600G



An ICCD camera monitors surface waves

Magnetic Damping of Wave Amplitudes Measured by a Laser Reflection System



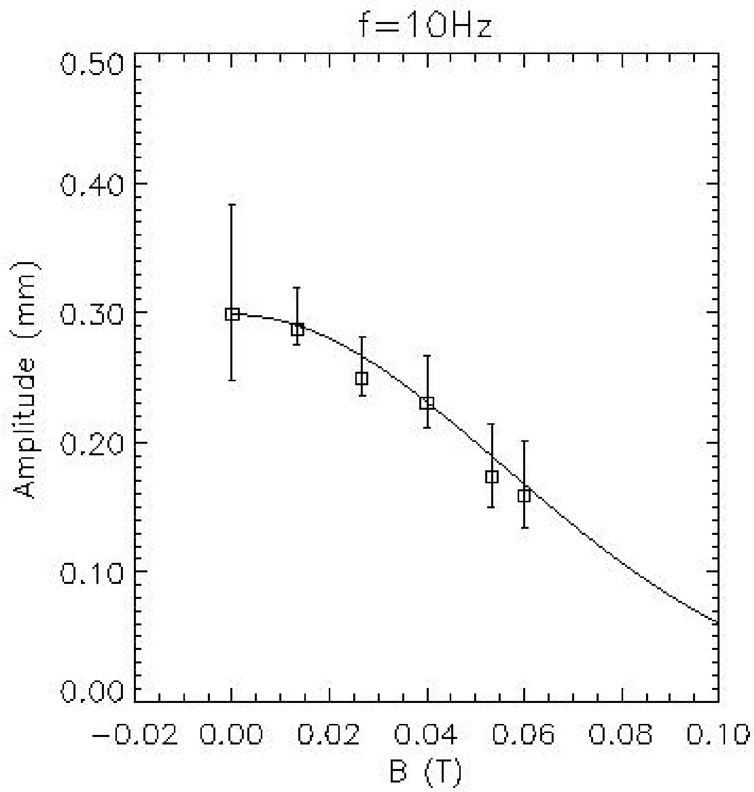


Linear Theory Including V×B Term Explains Magnetic Damping

$$\rho\omega^2 = \left(\rho g + Tk_x^2 + j_y B_x\right) k_x \tanh k_x h \left[1 + i\frac{B_x^2}{2\rho\eta\omega}\left(1 - \frac{2k_x h}{\sinh(2k_x h)}\right)\right]$$

- **Shallow water waves** ($k_x h \ll 1$): **no damping**
- **Deep water waves** ($k_x h \gg 1$) **damping rate:**

$$e^{-\frac{B_x^2 \omega \delta x}{2\eta\left(\rho\omega^2 + 2Tk_x^3\right)}}$$



Summary and Near Future Work

- Measured Dispersion relation of gallium surface waves agrees with theory at low frequency.
- Wave damping by magnetic field (at 600G), explained by a linear theory.
- Experimental apparatus being rebuilt, including a robust and flexible wave driver system, larger tanks, a multi-beam laser reflection system, PC-based controls and data acquisitions
- Collaborations with R. Rosner (U. Chicago) on simulations, H. Rappaport (Texas) on theory, and M. Abdou (UCLA) on fusion applications